

Relationship between the expansion speed and radial speed of CMEs confirmed using quadrature observations from SOHO and STEREO

Nat Gopalswamy, Pertti Mäkelä, and Seiji Yashiro

It is difficult to measure the true speed of Earth-directed CMEs from a coronagraph along the Sun-Earth line because of the occulting disk. However, the expansion speed (the speed with which the CME appears to spread in the sky plane) can be measured by such coronagraph. In order to convert the expansion speed to radial speed (which is important for space weather applications) one can use empirical relationship between the two that assumes an average width for all CMEs. If we have the width information from quadrature observations, we can confirm the relationship between expansion and radial speeds derived by Gopalswamy et al. (2009, CEAB, 33, 115, 2009). The STEREO spacecraft were in quadrature with SOHO (STEREO-A ahead of Earth by 87° and STEREO-B 94° behind Earth) on 2011 February 15, when a fast Earth-directed CME occurred. The CME was observed as a halo by the Large-Angle and Spectrometric Coronagraph (LASCO) on board SOHO. The sky-plane speed was measured by SOHO/LASCO as the expansion speed, while the radial speed was measured by STEREO-A and STEREO-B. In addition, STEREO-A and STEREO-B images measured the width of the CME, which is unknown from Earth view. From the SOHO and STEREO measurements, we confirm the relationship between the expansion speed (V_{exp}) and radial speed (V_{rad}) derived previously from geometrical considerations (Gopalswamy et al. 2009): $V_{\text{rad}} = \frac{1}{2} (1 + \cot w) V_{\text{exp}}$, where w is the half width of the CME. STEREO-B images of the CME, we found that CME had a full width of 75 degrees, so $w = 37.5$ degrees. This gives the relation as $V_{\text{rad}} = 1.15 V_{\text{exp}}$. From LASCO observations, we measured $V_{\text{exp}} = 897$ km/s, so we get the radial speed as 1033 km/s. Direct measurement of radial speed from STEREO gives 945 km/s (STEREO-A) and 1057 km/s (STEREO-B). These numbers are different only by 2.3% and 8.5% (for STEREO-A and STEREO-B, respectively) from the computed value.